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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT(S) : Leonard L. Diaddario, Jr.  
TITLE : USE OF N-ALLYL SUBSTITUTED AMINES  
AND THEIR SALTS AS BRIGHTENING  
AGENTS IN NICKEL PLATING BATHS  
APPLICATION NO. : 10/774,558  
FILED : February 9, 2004  
CONFIRMATION NO. : 8970  
EXAMINER : Edna Wong  
ART UNIT : 1753  
LAST OFFICE ACTION : April 19, 2006  
ATTORNEY DOCKET NO. : PVOZ 2 00016  
Cleveland, OH 44114  
October 2, 2006

DECLARATION

The undersigned declares as follows:

1. I, Leonard L. Diaddario, Jr. am the inventor listed in U.S. Patent Application No. 10/774,558, filed February 9, 2004.
2. I currently hold the position of Senior Research Chemist with Pavco, Inc. and have held this position for nine (9) years.
3. Prior to joining Pavco, I worked for seventeen (17) years in the field of Industrial Chemistry, holding such positions as Senior Chemist, Project Leader, and Staff Chemist with Celanese Corporation and Hoechst Celanese Corporation.

4. My educational background includes a doctorate degree in Analytical Chemistry from Wayne State University as well as a master's degree and bachelor's degree in chemistry also.

5. It is my opinion that the relevant art for the aforementioned patent application is the nickel plating bath art.

6. From my experience a person of ordinary skill in the nickel plating bath would be a person that has at least a bachelor's and/or master's degree in chemistry and two (2) to three (3) years of experience in the nickel plating field.

7. As part of my responsibilities as a Senior Chemist for Pavco, I was asked to review the aforementioned patent application and opine on the meaning of "n" in the following chemical formula  $[H_2C=CHCH_2N^+R_1R_2R_3]_nX^n^-$ .

8. This is a matter of ionic chemistry.

9. The concept is that the quaternary amine compound  $[H_2C=CHCH_2N^+R_1R_2R_3]_nX^n^-$  has a positive charge of +1 and that the n-valent inorganic or organic anion has a negative charge of n-.

10. It is known in ionic chemistry that a neutral charge is desired for the entire molecule, as such n number of the quaternary amine compounds must be present to neutralize the negative charge of the anion.

11. Therefore, n is the positive integer of the value of n-.

12. In the application, the following examples of  $X^{n-}$  are given: chloride, bromide, fluoride, sulfate, acetate and tetrafluoroborate and the anions have the following charges: chloride, bromide, fluoride, acetate and tetrafluoroborate all have a

charge of -1; and sulfate has a charge of -2. Therefore, for the examples of  $X^n$  given in paragraph 20 of the application,  $n$  would be 1 or 2.

13. It is my recollection that this would be an issue which would typically be taught in a freshmen chemistry class.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

By Leonard L. Diaddario, Jr.  
Printed Name: Leonard L. Diaddario, Jr.  
Date: 10/2/06

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www.synapses.co.uk Self-paced, self-learning Chemistry Course with lessons, exams and more.

1. [Yahoo! Answers](#) - Can't find what you're looking for? Try Yahoo! Answers.  
answers.yahoo.com

11. [Manchester College Chemistry course descriptions](#)  
... overview of the basic theory and principles of general and inorganic chemistry. ... and ionic compounds; application of thermodynamic principles and descriptive ...  
manchester.edu/Academics/departments/chemistry/course\_descriptions.htm - 21k - Cached - [More from this site](#) - [Save](#)

12. [Rockhurst University Department of Chemistry](#)  
Principles of General Chemistry (3) ... ionic bonding) as commonly taught in the first semester of a general chemistry course. ...  
www.rockhurst.edu/academic/chemistry/courses.asp - 29k - Cached - [More from this site](#) - [Save](#)

13. [The WebScience Project at IUPUI](#)  
C105/C111 Principles of Chemistry I. WarmUp exercises. GoodFors. Puzzles. Dimensional Analysis ... Ions and Ionic Compounds. Lewis Dot Structures. Shapes of ...  
webphysics.iupui.edu/webscience/chemistry\_archive.html - 14k - Cached - [More from this site](#) - [Save](#)

14. [Chemical Principles](#)  
Transition Metals and Coordination Chemistry. 20.1. The Transition Metals: A Survey ... Partial Ionic Character of Covalent Bonds. 13.7. The Covalent ...  
www.sas.upenn.edu/chem/ugrad/chemPrinciples.html - 18k - Cached - [More from this site](#) - [Save](#)

15. [Chemistry](#)  
... data, the systematic treatment of ionic equilibria and titrations, and the ... emphasizes the study of chemical principles in the context of contemporary ...  
newton.uor.edu/Departments&Programs/ChemistryDept/Chemistry.html - 18k - Cached - [More from this site](#) - [Save](#)

<http://search.yahoo.com/search?p=principles+ionic+chemistry&toggle=1&ei=UTF-8&psta...> 9/29/2006

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## CALIFORNIA INSTITUTE OF TECHNOLOGY

## CALTECH CATALOG

2006

The online version of the Caltech Catalog is provided as a convenience; however, the printed version is the only authoritative source information about course offerings, option requirements, graduation requirements, and other important topics.

**Chemistry**

**Ch 1 ab. General Chemistry.** 6 units (3-0-3) first term; 9 units (4-0-5) second term. Lectures and recitations dealing principles of chemistry. First term: electronic structure of atoms, periodic properties, ionic substances, covalent bonding representations of molecules and ions, shapes of molecules, Lewis acids and bases, Bronsted acids and bases, hybridization, resonance, bonding in solids. Second term: chemical equilibria, oxidation and reduction, thermodynamics, kinetics, intro organic chemistry and the chemistry of life. Graded pass/fail. Instructors: Lewis, Heath. Additional information concerning course can be found at <http://www.its.caltech.edu/~chem1>.

**Ch/APh 2. Introduction to Energy Sciences.** 9 units (4-0-5); third term. Prerequisites: Ch 1 ab, Ph 1 ab, Ma 1 ab. Energy production and transduction in biological, chemical, and nuclear reactions. Bioenergetics: energy sources and storage; control of biological energy flows: pumps, motors, and solar cells; circuitry of biological energy flows and biological energy transduction pathways. Chemistry of energy production and utilization: fossil fuel utilization and energy conversion pathways; artificial photosynthesis, solar cells, and solar energy conversion. Principles of nuclear energy production: nuclear energy decay; fission and fusion reactions, and reactor principles. Not offered on a pass/fail basis. Instructors: Lewis, Bellan, D. Newmeyer. The menu requirement of the Caltech core curriculum. Not offered 2006-07.

**Ch 3 a. Fundamental Techniques of Experimental Chemistry.** 6 units (0-5-1); first, second, third terms. Introduce principles and techniques of synthesis and analysis and develops the laboratory skills and precision that are fundamental to experimental chemistry. Freshmen who have gained advanced placement into Ch 41 or Ch 21, or who are enrolled in Ch 3 a, are encouraged to take Ch 3 a in the fall term. Graded pass/fail. Instructor: Staff.

**Ch 3 b. Experimental Procedures of Synthetic Chemistry.** 8 units (1-6-1); third term. Prerequisites: Ch 1 a, Ch 1 b. Instruction in fundamental synthesis, separation, and characterization procedures used in chemical research. Instructor: Staff.

**Ch 4 ab. Synthesis and Analysis of Organic and Inorganic Compounds.** 9 units (1-6-2). Prerequisites: Ch 1 (or the equivalent) and Ch 3 a. Previous or concurrent enrollment in Ch 41 is strongly recommended. Introduction to methods of separation, purification, and characterization used routinely in chemical research laboratories. Ch 4 a emphasizes spectral methods of analysis; Ch 4 b stresses applications of chromatography in addition to more classical separation techniques. First term; Ch 4 b, second term only. Instructor: Staff.

**Ch 5 ab. Advanced Techniques of Synthesis and Analysis.** Ch 5 a 12 units (1-9-2); Ch 5 b 9 units (1-6-2); third, second, and first terms, respectively. Prerequisite: Ch 4 ab. Ch 102 strongly recommended for Ch 5 b. Modern synthetic chemistry. Specified experiments may change from year to year. Experiments illustrating the multistep syntheses of natural products (Ch 5 a), coordination complexes, and organometallic complexes (Ch 5 b) will be included. Methodology will include advanced techniques of synthesis and instrumental characterization. Terms may be taken independently. Instructor: Dougherty. Part b not offered 2007.

**Ch 6 ab. Application of Physical Methods to Chemical Problems.** 10 units (0-6-4); second, third terms. Prerequisites: Ch 4 ab, and Ch 21 or equivalents (may be taken concurrently). Introduction to the application of modern physical methods to chemical problems, with emphasis in the area of molecular spectroscopy. Techniques including X-ray crystallography, laser spectroscopy, microwave spectroscopy, electron spin resonance, ultraviolet photoelectron spectroscopy, and Fourier transform cyclotron resonance spectroscopy are used to examine the structure, properties, and reaction dynamics of molecules in the solid phase, in solution, and at surfaces. Instructors: Okumura, Beauchamp, Collier.

**Ch 7. Advanced Experimental Methods in Bioorganic Chemistry.** 9 units (1-6-2); third term. Prerequisites: Ch 41 Bi/Ch 110, Ch 4 ab. Enrollment by Instructor's permission. Preference will be given to students who have taken Ch 5 a or Ch 5 b. Advanced laboratory course will provide experience in the powerful contemporary methods for polypeptide and oligonucleotide synthesis. Experiments will address nucleic acid and amino acid protecting group strategies, biopolymer assembly and product characterization. A strong emphasis will be placed on understanding the chemical basis underlying the success of these procedures. In addition, experiments to demonstrate the application of commercially available enzymes for use in organic transformations will be illustrated. Instructor: Hsieh-Wilson.

**Ch 10 abc. Frontiers in Chemistry.** 3 units (2-0-1); first, second terms. B units (1-6-1); third term. Open for credit to and sophomores. Prerequisites: Ch 10 c prerequisites are Ch 10 ab, Ch 3 a, and either Ch 1 ab, Ch 41 ab, or Ch 21 ab, with instructor's permission. Ch 10 ab is a weekly seminar by a member of the chemistry department on a topic of current research. The topic will be presented at an informal, introductory level. The other weekly session will acquaint students with the laboratory techniques and instrumentation used on the research topics. Ch 10 c is a research-oriented laboratory course, which will be supervised by a chemistry faculty member. Weekly class meetings will provide a forum for participants to discuss their projects. Graded pass/fail. Instructors: Barton, Dervan.

**Ch 14. Chemical Equilibrium and Analysis.** 6 units (2-0-4); third term. A systematic treatment of ionic equilibria in aqueous and nonaqueous solutions, complex ion formation, chelation, acidic reduction reactions, and some aspects of reaction mechanisms. Instructors: Rees, Richards.

**Ch 15. Chemical Equilibrium and Analysis Laboratory.** 10 units (0-6-4); first term. Prerequisites: Ch 1 ab, Ch 3 a, with instructor's permission. Laboratory experiments are used to illustrate modern instrumental techniques that are currently in industrial and academic research. Emphasis is on determinations of chemical composition, measurement of equilibrium constants, evaluation of rates of chemical reactions, and trace-metal analysis. Instructor: Staff.

**Ch 21 abc. The Physical Description of Chemical Systems.** 9 units (3-0-6); first, second, third terms. Prerequisites: Ph 2 ab, Ma 2 ab. Atomic and molecular quantum mechanics, spectroscopy, thermodynamics, statistical mechanics, and kinetics. Instructors: McKoy, Blake, Okumura.

**Ch 24 ab. Introduction to Biophysical Chemistry.** 9 units (3-0-6); second, third terms. Prerequisites: Ma 1 abc, Ph 21 a or Ph 2 ab. Fundamental physical chemistry, with emphasis on those topics most important in biology. Thermodynamics and its applications to aqueous solutions and living systems, membrane potentials and the thermodynamics of transport, reaction kinetics and mechanisms, transport properties, applications of molecular spectroscopy in biology, and statistical mechanical applications to biological polymers. Instructors: Rees, S. Chan.

**Ch 41 abc. Organic Chemistry.** 9 units (3-0-6); first, second, third terms. Prerequisite: Ch 1 ab or instructor's permission. Synthesis, structures, and mechanisms of reactions of organic compounds. Instructors: Grubbs, Dervan, Stoltz.

**Ch 80. Chemical Research.** Offered to B.S. candidates in chemistry. Units in accordance with work accomplished. Prerequisite: consent of research supervisor. Experimental and theoretical research requiring a report containing an appropriate description of the research work.

**Ch 81. Independent Reading in Chemistry.** Units by arrangement. Prerequisite: instructor's permission. Occasional work involving reading assignments and a report on special topics. No more than 12 units in Ch 81 may be used as electives in chemistry option.

**Ch 90. Oral Presentation.** 3 units (2-0-1); second term. Training in the techniques of oral presentation of chemical and biochemical topics. Practice in the effective organization and delivery of technical reports before groups. Graded pass/fail. Instructors: Zewail, Bikiel.

**Ch/ChE 91. Scientific Writing.** 3 units (1-0-2); third term. Training in the writing of scientific research papers. Each student must complete a 3,000-word paper styled after an article in the *Journal of the American Chemical Society* on a subject of scientific or biochemical relevance. The manuscript may be based on a paper submitted by the student for a previous class or on a report, but it must be the student's original writing and be within the intellectual scope of the chemistry and chemical engineering division. Each student will work individually with a faculty member under the supervision of the course instructor. Fulfills Institute scientific writing requirement. Instructor: Weitekamp.

**Ch 102. Introduction to Inorganic Chemistry.** 9 units (3-0-6); third term. Prerequisite: Ch 41 ab. Structure and bonding of inorganic species with special emphasis on spectroscopy, ligand substitution processes, oxidation-reduction reactions, and inorganic chemistry. Letter grades only. Instructor: Peters.

**Bi/Ch 110. Introduction to Biochemistry.** 12 units (4-0-8). For course description, see Biology.

**Bi/Ch 111. Biochemistry of Gene Expression.** 12 units (4-0-8). For course description, see Biology.

**Ch 112. Inorganic Chemistry.** 9 units (3-0-6); first term. Prerequisite: Ch 102 or instructor's permission. Introductory theory, ligand field theory, and bonding in coordination complexes and organotransition metal compounds. Systematics of synthesis, bonding, and reactivities of commonly encountered classes of transition metal compounds. Instructor: Bercaw

**Bi/Ch 113. Biochemistry of the Cell.** 12 units (4-0-8). For course description, see Biology.

**Ch 117. Introduction to Electrochemistry.** 6 units (2-0-4); second term. Discussion of the structure of electrode-electrolyte interface, the mechanism by which charge is transferred across it, and experimental techniques used to study electrode. Topics change from year to year but usually include diffusion currents, polarography, coulometry, irreversible electrode the electrical double layer, and kinetics of electrode processes. Not offered 2006-07.

**Ch 120 abc. Nature of the Chemical Bond.** 9 units (3-0-6) first term; 6 units (2-0-4) second term; 9 units (1-1-7) third term. Prerequisite: general exposure to quantum mechanics (e.g., Ph 2 ab, Ph 12 abc, or equivalent). Modern ideas of chemistry with an emphasis on qualitative concepts and how they are used to make predictions of structures, energetics, excited states and properties. Part a: The quantum mechanical basis for understanding bonding, structures, energetics, and properties of molecules (polymers, ceramics, metals alloys, semiconductors, and surfaces). The emphasis is on explaining chemical, mechanical and thermal properties of materials in terms of atomicistic concepts. Part b: The quantum mechanical basis for understanding transition metal systems with a focus on chemical reactivity. There will be an emphasis on organometallic complexes, or homogeneous catalysis, and on heterogeneous catalysis. Part c: The student does an individual research project using quantum chemistry computer programs to calculate wavefunctions, structures, and properties of real molecules. Not offered 07.

**Ch 121 ab. Atomic Level Simulations of Materials and Molecules.** 9 units (1-1-7) second, third terms. Prerequisite: Ph 2 ab, Ch 1 ab, or equivalent. Recommended: Ch 41 abc, Ch 21 a. Methods for predicting the structures and properties of molecules and solids. The course will highlight theoretical foundations and applications to current problems in the following: biological systems (proteins, DNA, carbohydrates, lipids); polymers (crystals, amorphous systems, copolymers); semiconductors (group IV, III-V, surfaces, defects); Inorganic systems (ceramics, zeolites, superconductors, and metals); and organometallic catalysis (heterogeneous and homogeneous). Both terms will involve the use of computers for building and calculating structures of interest. Part a covers the basic methods. Part b will focus on simulations applied to problems in petroleum chemistry. C recommended but not required for Ch 121 a. Not offered 2006-07.

**Ch 122 abc. Methods for the Determination of the Structure of Molecules.** 9 units (3-0-6); first, second, third terms. Prerequisite: Ch 21 abc or instructor's permission. Modern methods used in the determination of the structure of molecules. The three terms can be taken independently. Ch 122 a (small molecule X-ray crystallography) will be offered first term. Part not offered 2006-07. Instructor: Day.

**Ch 125 abc. The Elements of Quantum Chemistry.** 9 units (3-0-6); first, second, third terms. Prerequisite: Ch 21 ab or equivalent brief introduction to quantum mechanics. A first course in molecular quantum mechanics consisting of a quantitative treatment of quantum mechanics with applications to systems of interest to chemists. The basic elements of quantum mechanics: the electronic structure of atoms and molecules, the interactions of radiation fields and matter, scattering theory, and related theory. Instructors: Kupermann, McKoy, Weltekamp.

**Ch 126. Molecular Spectra and Molecular Structure.** 9 units (3-0-6); third term. Prerequisite: Ch 21 and Ch 125 a; concurrently, or instructor's permission. Quantum mechanical foundations of the spectroscopy of molecules. Topics include quantum theory of angular momentum, rovibrational Hamiltonian for polyatomic molecules, molecular symmetry and point group theory, electronic spectroscopy, interaction of radiation and matter. Instructor: Callier.

**Ge/Ch 127. Nuclear Chemistry.** 9 units (3-0-6). For course description, see Geological and Planetary Sciences.

**Ge/Ch 128. Cosmochemistry.** 9 units (3-0-6). For course description, see Geological and Planetary Sciences.

**Ch 130. Spectroscopy.** 9 units (3-0-6); third term. Discussion of various topics in lasers and their applications. Group applications to molecular structure and spectroscopy will also be discussed. Not offered 2006-07.

**Bi/Ch 132. Biophysics of Macromolecules.** 9 units (3-0-6). For course description, see Biology.

**Ch 135 ab. Chemical Dynamics.** 9 units (3-0-6); part a, third term; part b, second term. Prerequisites: Ch 21 abc and Ch 125 abc, or equivalent, or instructor's permission. Part a: Introduction to the dynamics of chemical reactions. Topics include cross sections, rate constants, intermolecular potentials, reactive scattering, nonadiabatic processes, statistical theories of unimolecular reactions, and the application of laser and molecular beam techniques to the study of reaction mechanisms: the quantum description of chemical reactions. The scattering matrix. The calculation of reaction cross sections, probability rate constants. Collision lifetimes and resonances. Classical trajectories. The two terms can be taken independently. Instructors: Okumura, Marcus, Kupermann.

**Ch/ChE 140 ab. Principles and Applications of Semiconductor Photoelectrochemistry.** 6 units (4-0-2); second, third terms. Prerequisite: AP/EE 9 or instructor's permission. The properties and photoelectrochemistry of semiconductors and semiconductor/liquid junction solar cells will be discussed. Topics include optical and electronic properties of semiconductors and electronic properties of semiconductor junctions with metals, liquids, and other semiconductors, in the dark and under illumination, with emphasis on semiconductor/liquid junctions in aqueous and nonaqueous media. Problems currently facing

semiconductor/liquid junctions and practical applications of these systems will be highlighted. The course will meet for five hour lectures per week and will be in a tutorial format with instruction predominantly from graduate students and postdoctoral fellows with expertise in the field. Instructor: Lewis. Given in alternate years; not offered 2006-07.

**Ch 142. Frontiers in Chemical Biology.** 4 units (2-0-2); second term. Prerequisite: Bi/Ch 110 or instructor's permission. Discussion of enzyme structure and function, and ligand-protein-nucleic acid interactions. Not offered 2006-07.

**Ch 143. Basic FT NMR Spectroscopy.** 9 units (3-2-4); second term. Prerequisite: Ch 41 abc. The course will cover NMR and applications, with emphasis on FT NMR and the principles of multipulse NMR techniques used in structural analysis, determination of relaxation times, INEPT, DEPT, NOSEY, and COSY. A number of NMR techniques will be illustrated with Chapman-Russell *FT NMR Problems* videodisc-based computer program, which features on-screen spectra at a variety of fields with, and without, decoupling, 2-D spectra, and so on. The practical use of NMR will be further demonstrated by 12 exercises using modern pulse FT NMR techniques with high-field spectrometers for structural analysis. Instructor: J. D. F.

**Ch 144 ab. Advanced Organic Chemistry.** 9 units (3-0-6); first term. Prerequisite: Ch 41 abc; Ch 21 abc recommend advanced survey of selected topics in modern physical organic chemistry. Topics vary from year to year and may include and theoretical organic chemistry; molecular recognition/supramolecular chemistry; reaction mechanisms and the tools them; reactive intermediates; materials chemistry; pericyclic reactions; and photochemistry. In 2006-07, only part a will (first term). Instructor: Dougherty.

**Ch 145. Bioorganic Chemistry of Proteins.** 9 units (3-0-6); second term. Prerequisite: Ch 41 abc; Bi/Ch 110 recommend advanced survey of current and classic topics in bioorganic chemistry/chemical biology. The content will vary from year to year and may include the structure, function, and synthesis of peptides and proteins; enzyme catalysis and inhibition; carbohydrate/glycobiology; chemical genetics; genomics and proteomics; posttranslational modifications; chemical tools to study cell dynamics; and enzyme evolution. Instructor: Hsieh-Wilson.

**Ch 146. Bioorganic Chemistry of Nucleic Acids.** 9 units (3-0-6); third term. Prerequisite: Ch 41 ab. The course will cover the bioorganic chemistry of nucleic acids, including DNA and RNA structures, molecular recognition, and mechanistic and covalent modification of nucleic acids. Topics include synthetic methods for the construction of DNA and RNA; separation techniques; recognition of duplex DNA by peptide analogs, proteins, and oligonucleotide-directed triple helical formation structure and RNA as catalysts (ribozymes). Given in alternate years; not offered 2006-07.

**Ch/ChE 147. Polymer Chemistry.** 9 units (3-0-6); second term. Prerequisite: Ch 41 abc. An introduction to the chemistry of polymers, including synthetic methods, mechanisms and kinetics of macromolecule formation, and characterization techniques. Offered 2006-07.

**ChE/Ch 148. Polymer Physics.** 9 units (3-0-6). For course description, see Chemical Engineering.

**Ch 153. Advanced Inorganic Chemistry.** 9 units (2-0-7); second term. Prerequisites: Ch 112 and Ch 21 abc or concurrent registration. Topics in modern inorganic chemistry. Electronic structure, spectroscopy, and photochemistry with emphasis on examples from the modern research literature. Instructor: Gray.

**Ch 154 ab. Organometallic Chemistry.** 9 units (3-0-6); second, third terms. Prerequisite: Ch 112 or equivalent. A general discussion of the reaction mechanisms and the synthetic and catalytic uses of transition metal organometallic compound. Second term: a survey of the elementary reactions and methods for investigating reaction mechanisms. Third term: contemporary inorganic and organometallic synthesis, structure and bonding, and applications in catalysis. Instructors: Bercaw, Peters

**ChE/Ch 155. Chemistry of Catalysis.** 9 units (3-0-6). For course description, see Chemical Engineering.

**Ch 163. Lectures-Seminars in Physical Chemistry.** 6 units (2-0-4); third term. Not offered 2006-07.

**ChE/Ch 164. Introduction to Statistical Thermodynamics.** 9 units (3-0-6). For course description, see Chemical Engineering.

**ChE/Ch 165. Chemical Thermodynamics.** 9 units (3-0-6). For course description, see Chemical Engineering.

**Ch 166. Nonequilibrium Statistical Mechanics.** 9 units (3-0-6); third term. Prerequisite: Ch 21 abc or equivalent. Transport processes in dilute gases; Boltzmann equation; Brownian motion; Langevin and Fokker-Planck equations; linear response theory; time-correlation functions and applications; nonequilibrium thermodynamics. Instructor: Marcus.

**BMB/BI/Ch 170. Principles of Three-Dimensional Protein Structure.** 9 units (3-3-3). For course description, see Biochemistry and Molecular Biophysics.

**ESE/Ge/Ch 171. Atmospheric Chemistry I.** 9 units (3-0-6). For course description, see Environmental Science and Earth Sciences.

**ESE/Ge/Ch 172. Atmospheric Chemistry II.** 3 units (3-0-0). For course description, see Environmental Science and Engineering.

**BMB/Bi/Ch 174. Biophysical Chemistry.** 9 units (3-0-6). For course description, see Biochemistry and Molecular Biology.

**ESE/Ch/Ge 175 ab. Environmental Organic Chemistry.** 9 units (3-0-6). For course description, see Environmental Engineering.

**Ch 180. Chemical Research.** Units by arrangement. Offered to M.S. candidates in chemistry. Graded pass/fail.

**Ch 212. Bioinorganic Chemistry.** 9 units (3-0-6); third term. Prerequisites: Ch 112 and Bi/Ch 110 or equivalent. Current topics in bioinorganic chemistry will be discussed, including metal storage and regulation, metalloenzyme structure and reactivity, biological electron transfer, metalloprotein design, and metal-nucleic acid interactions and reactions. Instructor: Barton. Offered alternate years; not offered 2006-07.

**Ch 213 abc. Advanced Ligand Field Theory.** 12 units (1-0-11); first, second, third terms. Prerequisite: Ch 21 abc or concurrent registration. A tutorial course of problem solving in the more advanced aspects of ligand field theory. Recommended only for students interested in detailed theoretical work in the inorganic field. Instructors: Gray, staff.

**Ch 221. Electron Transfer Reactions in Chemistry and Biology.** 6 units; second term. Prerequisite: Ch 21 abc. Fundamentals of electron transfer reactions. Molecular (statistical) theory, dielectric continua, electronic matrix elements, Franck-Condon principle, relevant thermodynamics, reorganization energy, quantum effects, charge transfer spectra, solvent dynamics, in solution at metal electrode-liquid, modified electrode-liquid, semiconductor electrode-liquid, and liquid-liquid interface theory. Reactions in photosynthetic reaction centers and in other proteins. Not offered 2006-07.

**Ch 224. Advanced Topics In Magnetic Resonance.** 9 units (2-0-7); third term. Prerequisite: Ch 125 abc or Ph 125 a concurrent registration or equivalent; Ch 122 b or equivalent. A detailed presentation of some of the important concepts of magnetic resonance unified by the spin density operator formalism. Topics will include both classic phenomena and recent development, especially in solid-state and two-dimensional NMR. Instructor: Weitekamp. Not offered 2006-07.

**Ch 227 ab. Advanced Topics in Chemical Physics.** 9 units (3-0-6); part a second term; part b third term. Prerequisite: Ch 125 abc or Ph 125 abc or equivalent. The general quantum mechanical theory of molecular collisions will be presented in detail. Classical, semi-classical, and other approximations. Applications to inelastic and reactive molecule-molecule and inelastic molecule collisions. Part a not offered 2006-07. Instructor: Heath.

**Ch 228. Dynamics and Complexity in Physical and Life Sciences.** 9 units (3-0-6); third term. This course is concerned with the dynamics of molecular systems, with particular focus on complexity, the elementary motions that lead to functions in biological assemblies. It will address principles of dynamics as they relate to the nature of the chemical bond. An overview of modern techniques, such as those involving lasers, NMR, and diffraction, for unraveling dynamics in complex systems. A range of areas of physics, chemistry, and biology—from coherence and chaos to molecular recognition and self-assembly. Instructor: Zewail.

**Ch/Bi 231. Advanced Topics in Biochemistry.** 6 units (2-0-4); third term. Transcriptional Regulation in Eukaryotes. Subunit structure of eukaryotic RNA polymerases and their role in transcriptional reactions; the composition of eukaryotic promoters, including regulatory units; general and specific transcription factors; developmental regulatory circuits and functional structural motifs involved in DNA binding and transcriptional initiation and control. Not offered 2006-07.

**Ch 242 ab. Chemical Synthesis.** 9 units (3-0-6); first, second terms. Prerequisite: Ch 41 abc. An integrated approach to synthetic problem solving featuring an extensive review of modern synthetic reactions with concurrent development of synthesis design. Part a will focus on the application of modern methods of stereocontrol in the construction of stereocomplex acyclic systems. Part b will focus on strategies and reactions for the synthesis of cyclic systems. Instructors: Stoddart, Sharpless.

**Ch 244. Topics In Chemical Biology.** 9 units; second term. Current topics at the interface of chemistry and biology. Not offered 2006-07.

**Ch 247. Organic Reaction Mechanisms.** 6 units (2-0-4); third term. A mechanistic view of free-radical reactions using methods from biological systems. Topics: Initiation, termination, and propagation of radical reactions *in vivo*, mechanisms of lipid peroxidation, spin labeling, photosynthesis, oxygen radicals and oxygen toxicity, and radical reactions in proteins and nucleic acids. Not offered 2006-07.

**Ch 250. Advanced Topics in Chemistry.** *Units and term to be arranged.* Content will vary from year to year; topics a according to interests of students and staff. Visiting faculty may present portions of this course. Not offered 2006-07.

**Ch 280. Chemical Research.** *Hours and units by arrangement.* By arrangement with members of the faculty, properly graduate students are directed in research in chemistry.

California Institute of Technology 1200 East California Boulevard Pasadena California 91125 (626) 3